STATUS OF WESTERN RIVER CRUISER *Macromia magnifica* McLachlan IN BRITISH COLUMBIA

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ABSTRACT

The Western River Cruiser, *Macromia magnifica* McLachlan, is a large, boldly patterned dragonfly of warm, clear streams and lakes in western North America. In British Columbia, the species is restricted to a few lakes and warm streams in the Fraser Valley, Shuswap Lake, Okanagan Valley and Christina Lake areas. Recent observation or collection records are not known from the Fraser Valley and Shuswap Lake. Little is known of the biology of the species and no real trend information is available. Possible threats include shoreline development (including loss of riparian vegetation), pesticide contamination, eutrophication and predation by introduced fish. Recommendations include more focused inventory, basic research into the species' biology, maintenance of natural shorelines where possible and control of introduced predatory fish.

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1 SPECIES INFORMATION

1.1 Name and Classification

Macromia magnifica was described by McLachlan in Selys (1874, Bull. Acad. Belg. (2)37:22). *Macromia* is derived from the Greek *macro*, large, and omi, shoulders—the "large shoulders" presumably describe the powerful thorax of these large, strong fliers. For this large, brightly-coloured dragonfly, the specific epithet magnifica needs no explanation.

Walker (1937) described the species *M. rickeri* from individuals from the wetter parts of the species' range in the Fraser Valley and Shuswap Lake regions of British Columbia; however, D. Paulson (pers. comm.) and Needham et al. (2000) consider these populations to be merely melanic forms of M. magnifica; the degree of melanism in a population is correlated with the annual rainfall of its location.

The genus *Macromia* is placed in the family Macromiidae by Cannings (2002) and Dunkle (2000), although this family is often treated as a subfamily of Libellulidae (e.g., Needham et al. 2000). The genus is an extremely large one, but only seven of the more than 130 species live in North America; only one occurs in British Columbia (Dunkle 2000).

Synonyms:
Macromia rickeri Walker.

1.2 Description

M. magnifica is a large, robust dragonfly; females average 71 mm long, males are marginally shorter at 69 mm (Cannings 2002). The face is yellow with two dark cross-bands; the eyes are described as opalescent brown by Dunkle (2000), but often appear blue (as in Figure 1). The body is brown. The thorax is slightly metallic and faintly pruinose with age; it is encircled by a single, mid-lateral clay-yellow band. The wings are clear, bordered in the front by yellow costal veins; the legs are unusually long. The upper surfaces of the abdominal segments are broadly banded with yellow (Dunkle 2000; Needham et al. 2000; Cannings 2002). In the dark form (previously described as *M. rickeri*) in

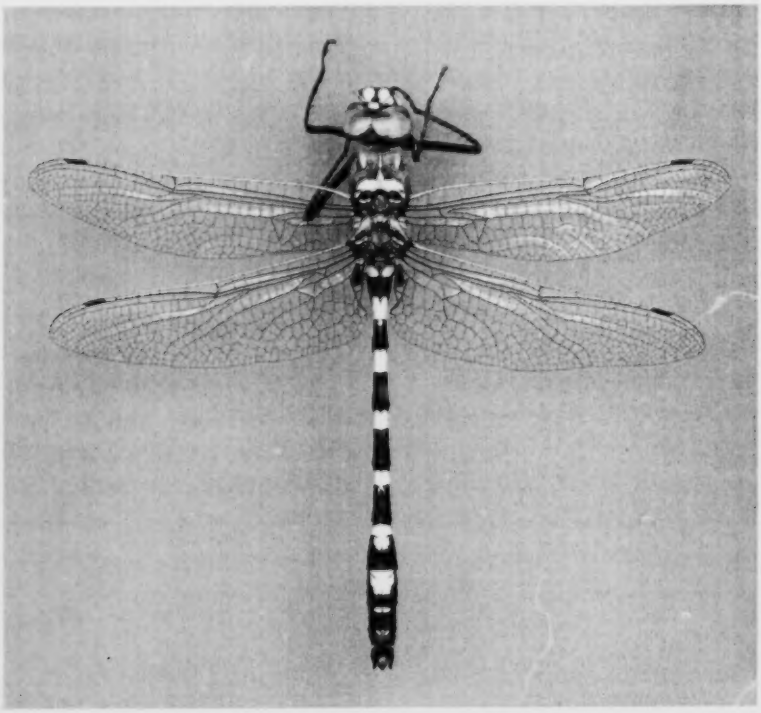

Figure 1. Male *Macromia magnifica*, Yakima River, Washington. Scan of live dragonfly by D. Paulson.

the Fraser Valley and Shuswap Lake regions, the abdominal bands on segments 3-6 are reduced to small, divided spots (Cannings 2002).

The larvae are large, with long, banded, spider-like legs; their most distinctive feature is a horn-like projection between the eyes (Cannings 2002).

2 BIOLOGY

2.1 General

As in other dragonflies, larvae are aquatic and adults terrestrial. In general, individuals of *Macromia* spend two years as a larvae before transforming into adults (Dunkle 2000).

2.2 Phenology

The flight period in British Columbia is approximately early June to late September (Cannings 2002); recorded dates are 13 June to 8 September (S. Cannings, unpubl. data). However, a teneral female was recorded at Cultus Lake in May 1933 (exact date not recorded; Walker and Corbet 1975). At Cultus Lake, mature larvae (i.e., fully developed, ready to emerge) have been collected from 28 May to 23 June (Whitehouse 1941; Walker and Corbet 1975). Emergence there mostly takes place in the last week of June, but has been recorded as late as 3 July (Walker and Corbet 1975). In Washington State, the adults were at their height on 27 July, but "rapidly disappeared after August 7, and none were seen after August 24" (Kennedy 1915).

Most mature larvae captured by Whitehouse (1941) emerged, or attempted to emerge, in the late evening. Seven of eight larvae that attempted to emerge climbed up sticks "in the early evening and remained with head and shoulders out of the water until dark. Transformation took place between 10 and 11 p.m." A single larva emerged about 8:00 a.m., and had spread her wings by 11:00 a.m. At Cultus Lake, D. Paulson (pers. comm.) found three exuviae; all were about 3 m from the lakeshore and between 2.5 and 3 m above ground level, one on a building and two on trees.

2.3 Reproduction

Males search for females by patrolling in a swift, direct flight over open water a few metres from shore. After patrolling the water in one direction, the return trip is often made over land (LaRivers 1938; Walker and Corbet 1975; Dunkle 2000). Along the Okanagan River, males patrolled "two or three feet above the water and a few yards from the shore" (Walker 1927). Females visit the oviposition sites primarily in the morning; this is why males are usually seen patrolling between 7:00 and 10:00 a.m., rarely in the afternoon (Kennedy 1915). At Newport Beach, Okanagan Lake, males patrolled most actively before 11:00 a.m. (R.C. Cannings and R.J. Cannings, pers. comm.).

When a male encounters a female and is successful in establishing copulation, the pair generally flies away from water over the surrounding vegetation, and ends "in a long period of copulation while resting on some bush or tree" (Kennedy 1915).

Kennedy (1915) describes oviposition along Status Creek, California: "...the female would fly several times back and forth over a short beat of 40 or 50 feet, striking her abdomen on the surface of the water at 3 to 5 foot intervals." At Kawkawa Lake, near Hope, Whitehouse (1941) noted that "the ovipositing female flew quickly some eight or ten inches above the water, swooping down every five or six feet to touch the tip of her abdomen."

2.4 Survival

No information.

2.5 Physiology

No information.

2.6 Movements/Dispersal

No information.

2.7 Nutrition and Interspecific Interactions

Both adults and larvae are predaceous. The larvae presumably forage by hiding within root mats along lake and stream edges (Kennedy 1915; R.A. Cannings, pers. comm.). Research by Williams (1978) on the larvae of several other species of *Macromia* found that these species showed diverse foraging behaviour; it would be therefore unwise to generalize the habits of *M. magnifica* from one or two observations. In Okanagan Lake, the dominant large aquatic insect that might be prey for these larvae is the mayfly *Hexagenia limbata*.

Adults forage mostly from afternoon to late twilight over open fields (Dunkle 2000). Like other large dragonflies, they are strong fliers and often forage long distances from water (Cannings 2002) and, like other large dragonflies, presumably eat any flying insects smaller than themselves.

2.8 Behaviour/Adaptability

For feeding behaviour, see Section 2.6. For breeding behaviour, see Section 2.2.

3 HABITAT

3.1 Habitat Requirements

Larvae inhabit clean, often sand-bottomed, lowland rivers and lakes (Dunkle 2000). Walker and Corbet (1975) describe the habitat as: "rapid streams, the nymphs being amongst matted tree-roots suspended in the water, or sometimes under stones." This inexplicably ignores the lakeshore habitat used by a number of populations, being based primarily on Kennedy's (1915) habitat description (see below). A number of other species of river-inhabiting dragonflies, including the Pale Snaketail (*Ophiogomphus severus*), Olive Clubtail (*Stylurus olivaceus*) and Nez Perce Dancer (*Argia emma*), show a similar pattern of occupying clear lakes toward the northern end of their range.

The shore of Cultus Lake is mostly stony or bedrock, with small areas of sand; emergent vegetation consists of scattered bulrush (*Scirpus lacustris*) and small clumps of common cattail (*Typha latifolia*) or pond-lily (*Nuphar polysepalum*; from a description by W.E. Ricker in Walker and Corbet 1975).

On Status Creek, Washington, a larva was found in an intricate mass of fibrous alder (*Alnus* sp.) roots, and exuviae were found on the alder trunks and branches above. Adult males patrolled the open pools of the river (Kennedy 1915). At Cultus Lake, larvae were found beneath stones near the lake's edge (Whitehouse 1941). R.A. Cannings (pers. comm.) found a larva within a fibrous root cluster at the outlet of Vaseux Lake. However, the fact that males patrol well offshore in large lakes such as Okanagan Lake may indicate that larvae also inhabit the sandy or silty depths of these lakes. Whitehouse (1941) noted oviposition in Kawkawa Lake, where "the water was five to fen feet deep, with a muddy bottom and reeds well below the surface."

Adults presumably have broad habitat requirements, needing only open areas with abundant flying insects.

3.2 Trends in Habitat Quality and Quantity

Because the habitat requirements of the larvae are imprecisely known, it is difficult to determine whether there has been a decline in quality and quantity of habitat. The Okanagan River has been channelled (i.e., straightened and levelled, with drop structures put in place; Figures 2, 3 and 4) and presumably this has reduced both quantity and quality of habitat, but no studies have been attempted to demonstrate this. D. Paulson (pers. comm.) has observed that the species can be common along similar channels in eastern Washington, and Walker (1927) described *Macromia* as "scarce" along the original Okanagan River at Penticton, which makes it difficult to make a case for a decline in habitat quality. However, the quantity of clear, flowing water habitat in the south Okanagan obviously declined when the river was straightened.

M. magnifica shares its riverine habitats with the Sinous Snaketail (*Ophiogomphus occidentis*), Stylurus olivaceus, Argia emma and, at Christina Creek, with the rare River Jewelwing (*Calopteryx aequabilis*). In lake habitats it flies with the Pronghorn Clubtail (*Gomphus graslinellus*) and, occasionally, S. olivaceus.

3.3 Present Habitat Status

The Okanagan River has largely been altered by channelization, as described in Section 3.2. The South Thompson River is relatively natural, except for agricultural development along its banks and the proliferation of some exotic riparian species, such as Russian olive (*Elaeagnus angustifolia*). Residential, tourism and recreational development has altered much of the accessible shorelines of the lakes in the Okanagan and Shuswap regions, as well as Cultus, Kawkawa and Christina lakes. Christina Creek remains largely in a natural state, with some residential development along its western shores.

3.4 Protection/Ownership

A number of sites are protected or managed for conservation, especially in the Okanagan; however, many of the provincial parks within the distribution of this species are managed primarily for recreation (swimming and boating) and may not adequately protect the littoral and shoreline zones. Protected areas include South Okanagan Wildlife Management Area, Vaseux-Bighorn National Wildlife Area, Vaseux Lake Provincial Park, Okanagan Mountain Provincial Park, Sunoka Provincial Park, Okanagan Lake Provincial Park, Bear Creek Provincial Park, Fintry Provincial Park, Ellison Lake Provincial Park, Kalamalka Lake Provincial Park, Christina Lake Nature Park (locally managed), Christina Lake Provincial Park, Gladstone Provincial Park and Cultus Lake Provincial Park. The Nature Conservancy of Canada and Turtle Island Earth Stewards are working to secure conservation covenants on private lands along Christina Creek (K. Blake, R. Durand, pers. comm.).

4 DISTRIBUTION

4.1 Global/North American

Restricted to western North America, including northern Mexico. Ranges from southern British Columbia south through Washington, Oregon and western Idaho to central California and Nevada; a disjunct, southern population ranges from Arizona south through Chihuahua to Hidalgo, Mexico (Dunkle 2000; Needham et al. 2000). Needham et al. (2000) record it from Saskatchewan as well, but this is undoubtedly an error.

In Washington State, Paulson (1999) describes the species as "uncommon" in the eastern lowlands; there is an old, unconfirmed record from Seattle.

4.2 British Columbia

Found in warm lakes and clear, warm, lowland rivers in southern British Columbia: Fraser Valley (Cultus and Kawkawa Lakes), Shuswap Lake, Okanagan

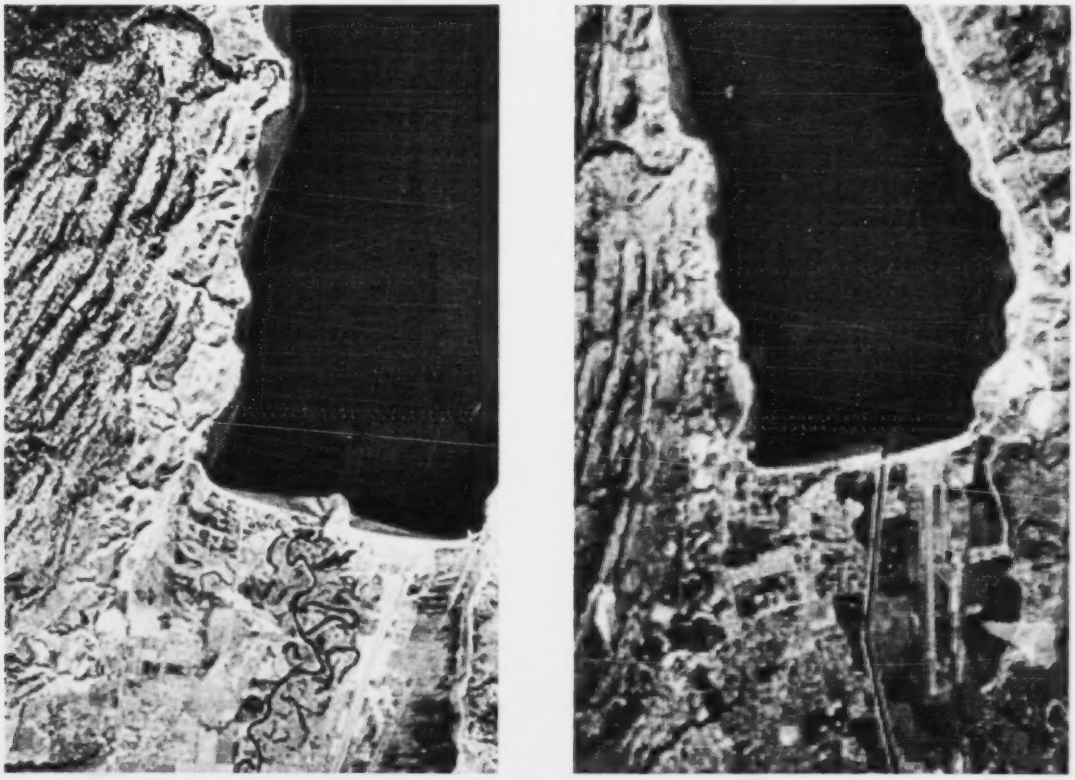

Figure 2. Left: Air photo (BC 800-31) taken of the Okanagan River entering Skaha Lake at Penticton, 1949 (south at top). Right: The same view, taken in 1982 (BC 82024:204).

Figure 3. The Okanagan River flowing through the large marsh at the outlet of Okanagan Lake, Penticton, in 1912. Photo: Penticton Museum.

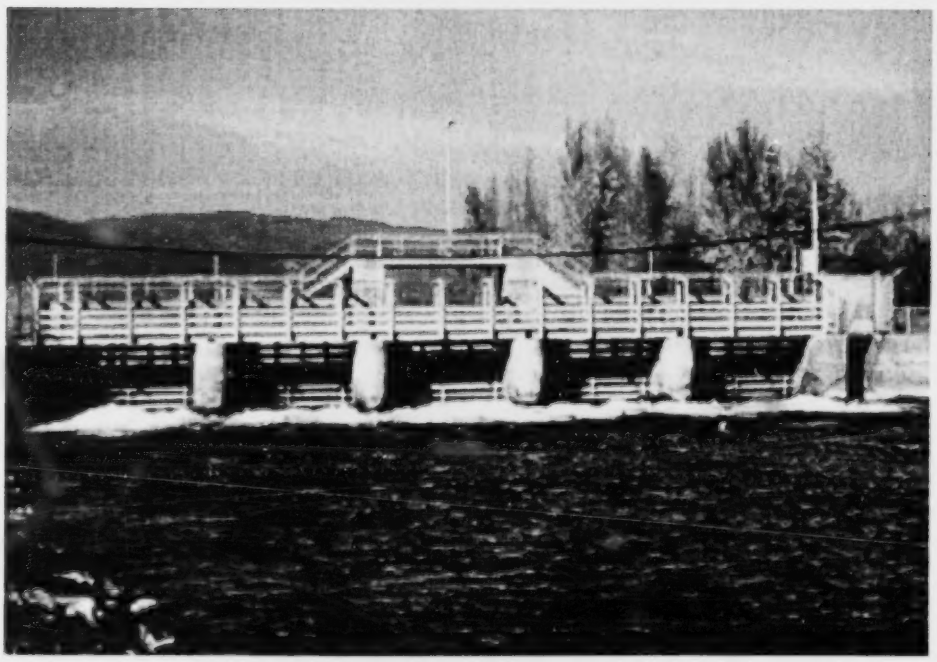

Figure 4. The same site pictured in Figure 3, as seen in 1983. The lake and river levels are now controlled by a dam and the river has been straightened, channelled and bordered by dykes. Photo: R.A. Cannings.

Valley and Christina Lake/Christina Creek. Not known from the Columbia or Kootenay valleys, nor from Vancouver Island (Scudder et al. 1976; Cannings and Stuart 1977; Cannings et al. 1999; Cannings 2000). A dragonfly survey of the Fraser Valley in 1996 failed to locate any individuals of this species, but probably not enough effort was made to look for this species in particular (R. Kenner, pers. comm.). There are no recent records from Shuswap Lake, but the species has not been searched for in that region in recent years; there may be undiscovered populations along the South Thompson River as well.

5 POPULATION SIZES AND TRENDS

5.1 Population Size

No estimates have been made. However, Cannings (2002) describes the species as "uncommon" in British Columbia. Along the Okanagan River at Penticton on 22 and 23 July 1926, Walker (1927) describes the

Figure 5. Rangewide distribution of *Macromia magnifica* (adapted from Dunkle 2000; Nunnallee and Paulson 2002).

patrolling males as "so scarce that their capture was practically hopeless." On one hot summer morning in early August 1998, I counted 15 males flying along a 3-km stretch of the eastern shore of Okanagan Lake north of Naramata (S. Cannings, pers. obs.). Similarly, approximately 20 were counted foraging along a 4-km stretch of the Kettle Valley Railroad right-of-way north of Naramata (R.J. Cannings, pers. comm.). On 14 July 1971, D. Paulson (pers. comm.) collected seven and saw twice that number foraging over the road at Cultus Lake. Using these observations as a very rough guide, the minimum population is on the order of 3000-6000, but may be considerably more than this.

5.2 Population Trends

No information. However, the species has not been recorded in the Fraser Valley since 1971 (Kenner 2000; D. Paulson, pers. comm.). This may indicate a decline in abundance there, or even extirpation, but confirmation of a decline will require additional, focused inventory. Walker's (1927) description of the species as "scarce" along the Okanagan River at

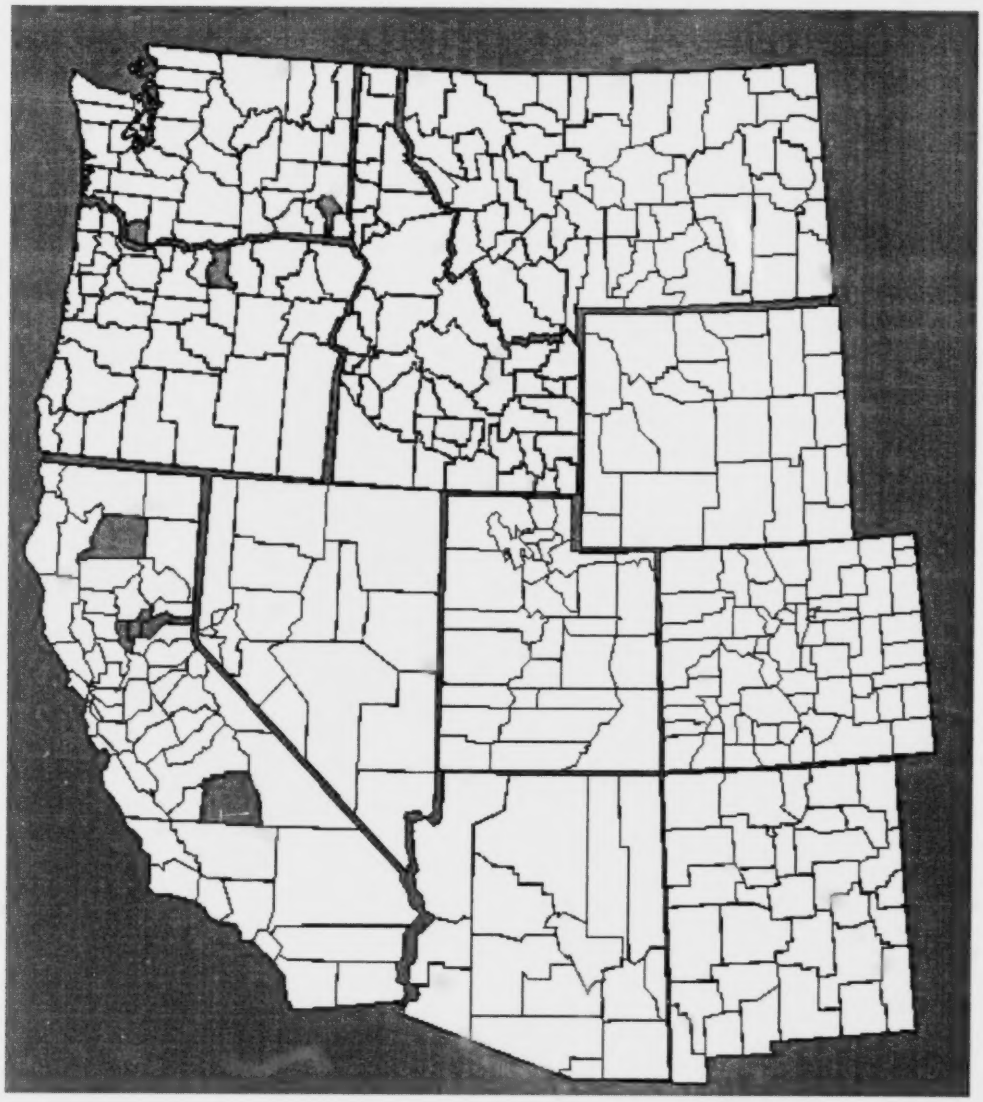

Figure 6. County distribution of *Macromia magnifica* in the western United States (Nunnallee and Paulson 2002).

Penticton makes it difficult to suggest a significant decline as a result of river channelling there. Paulson (1999) suggests that it "may be declining" in Washington State.

6 LIMITING FACTORS AND THREATS

6.1 Habitat Loss/Degradation

Until habitat needs are more clearly defined, it is difficult to discuss habitat loss. The channelling of the Okanagan River may have degraded some of the riverine habitat within this species' range in British Columbia. However, *Macromia* still patrols at least parts of this watercourse, and the fact that Walker (1927) found males of the species "scarce" along the Penticton reaches of the Okanagan River also indicates that any declines may not have been that significant. The effects of intensive use of beaches for recreational swimming and boating are not known. However, I know of no records of larval emergence on the main beaches in the Okanagan, and the species is apparently rare or absent now at Cultus Lake in the Fraser Valley—both areas that are used by hundreds, if not thousands, of people daily in the summer. One larva was seen emerging after crawling over the small beach at Okanagan Lake Provincial Park in 1974 (S. Cannings, pers. obs.). More focused study is needed to measure these threats. Foreshore development continues at Christina Lake, although the habitat along Christina Creek remains relatively natural (R. Walker, pers. comm.). The Nature Conservancy of Canada is negotiating with landowners along that watercourse to protect riparian habitat through conservation covenants (K. Blake, pers. comm.).

6.2 Exotic Species

The Okanagan River and associated lakes have had their fish populations altered considerably through the introduction of predatory species such as Large-

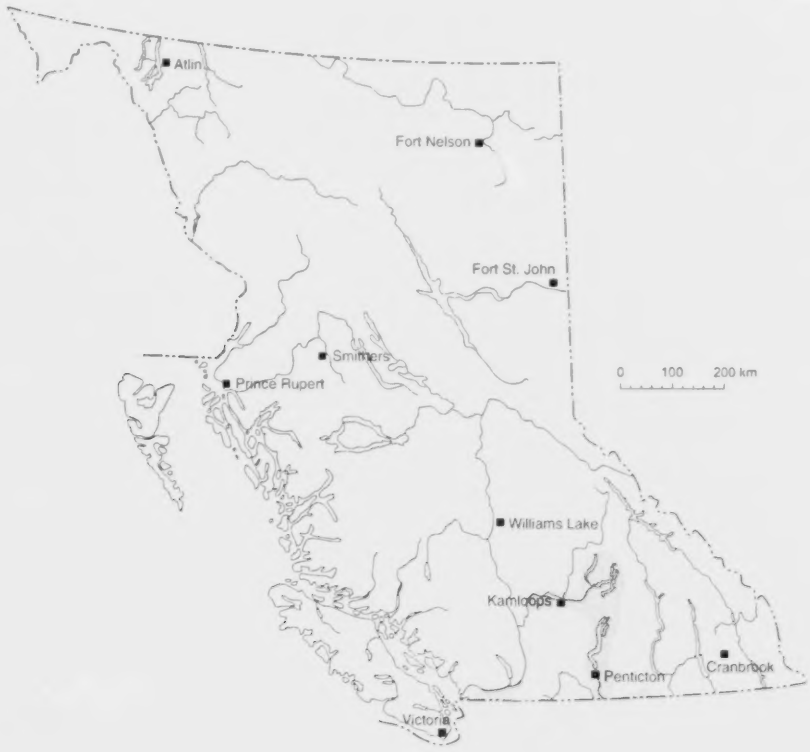

Figure 7. Distribution of *Macromia magnifica* in British Columbia (from Cannings and Stuart 1977; Cannings 2002).

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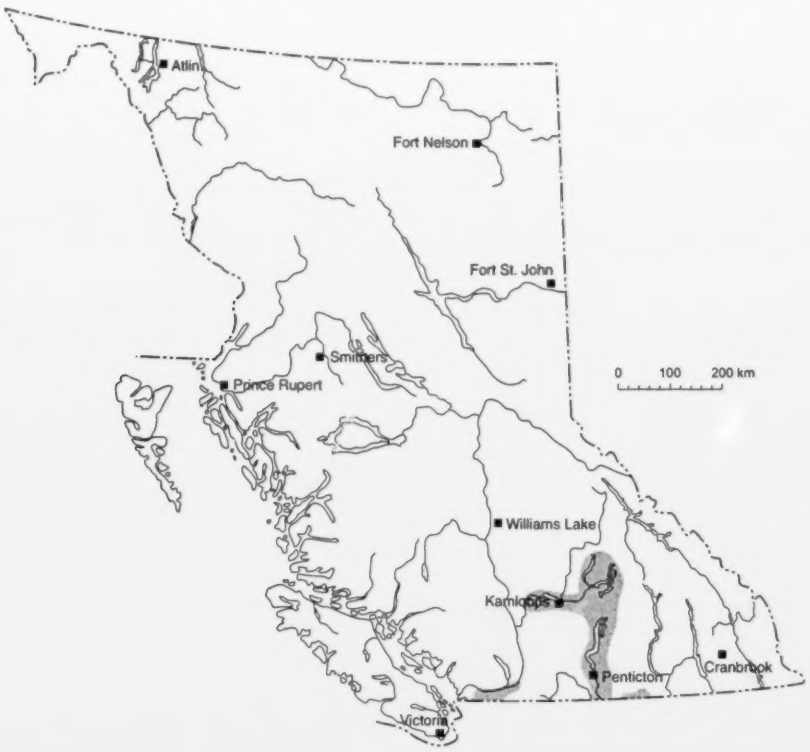

Figure 7. Distribution of *Macromia magnifica* in British Columbia (from Cannings and Stuart 1977; Cannings 2002).

mouthed Bass (*Micropterus salmoides*), Smallmouthed Bass (*M. dolomieui*), Pumpkinseed (*Lepomis gibbosus*), Yellow Perch (*Perca flavescens*), Black Crappie (*Pomoxis nigromaculatus*) and Carp (*Cyprinus carpio*). Christina Creek also has substantial populations of all the above species, with the exception of Black Crappie; these exotic species have entered it primarily via introductions into Roosevelt Lake, the reservoir above the Grand Coulee Dam, south of the U.S. border (L. Brazier, B. Jantz, pers. comm.).

Fish are major predators of odonate larvae (Hilton 1987; Corbet 1999). In an experimental study in North Carolina, 10 times as many dragonfly larvae were found within fish exclusion cages as outside them (Morin 1984). Specifically, bass (*Micropterus* spp.), sunfish (*Lepomis*) and perch (*Perca* spp.) are all known to prey heavily on odonates. In an Iowa study, odonate larvae made up 62-70% of the food of Largemouth Bass greater than 9 cm long (Wright 1946). Large dragonfly larvae were the main food of perch in a Russian study (Pushkin et al. 1979). In Minnesota, coenagrionid damselfly and libellulid dragonfly larvae were prominent among food of Lepomis sunfish (Crowder and Cooper 1982). In Tennessee, Lepomis sunfish preyed heavily on the larvae of *Epitheca cynosura* (a medium-sized corduliid dragonfly); the mean number of larvae per fish when caught was 30 (Martin 1986).

In the Okanagan system, Carp not only eat the larvae, but undoubtedly have had a major negative impact on the vegetation structure of the littoral zone (Cannings et al. 1987).

The Okanagan system and Christina Lake/Creek have been invaded by Eurasian water-milfoil (*Myriophyllum spicatum*). This aquatic weed is said to be "out of control" at the outlet of Christina Lake (Okanagan Similkameen Boundary Fisheries Partnership 2002). Its effect on habitat suitability for *M. magnifica* is unknown, but its presence is probably deleterious where large, dense mats form.

6.3 Pollution/Pesticides

No information is available on the effects of pesticides on this species. Pesticides are a potential problem, especially in the South Okanagan, where the Okanagan River flows through many orchard and vineyard lands. Eutrophication through agricultural runoff may be a problem, especially in the Okanagan region. Sewage inputs of nitrates and phosphates have been reduced dramatically in the Okanagan through tertiary treatment of sewage in the major centres; however, smaller centres and rural areas are not treating sewage in this manner.

7 SPECIAL SIGNIFICANCE OF THE SPECIES

The only member of its family in British Columbia and one of only two or three large dragonflies inhabiting southern British Columbia's warm rivers and sandy-shored, large lakes. This species may thus prove to be a good indicator of stream and lake ecosystem health for these habitats.

8 EXISTING PROTECTION OR OTHER STATUS

There is no protection offered to invertebrates in British Columbia. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has not yet assessed dragonflies; therefore, this species has not been given other status by COSEWIC and, by extension, does not have status under the federal Species at Risk Act. Nor has it been given other status under the U.S. Endangered Species Act. It is given a global rank of G4 by NatureServe (2002b), which indicates a species that is "apparently secure" at present, but for which there are some potential future conservation concerns. Provincially, it is ranked S3 by the BC Conservation Data Centre (BCCDC 2003), which places it on the Blue List of species considered vulnerable or sensitive, although not immediately threatened or endangered.

9 RECOMMENDATIONS AND MANAGEMENT OPTIONS

9.1 Inventory and Research

Since this species is little studied throughout its range, more research and inventory will be needed to develop comprehensive management recommendations.

Because its lakeshore and riverside habitat is often

shared with intensive human use, more precise knowledge of larval distribution would assist in making sound management decisions (Cannings et al. 1999). As mentioned in Section 4.2, there have been no recent, adequate inventories in the Fraser Valley and Shuswap Lake areas. In the Okanagan, no inventory has been undertaken that specifically focuses on *M. magnifica*; it is very probable that the 1997 survey (Cannings et al. 1998) missed a number of localities in the south Okanagan. Although the species was recently reconfirmed at Christina Lake and Christina Creek (Cannings et al. 1999), the Kettle River has not been well surveyed and may also host a population of this species.

9.2 Riparian Zone Management

The protection of riparian zones is probably vital to maintain larval habitat in streams; riparian shrubs and trees both protect the stream banks from erosion and contribute to in-stream structure that is apparently used by larvae. *M. magnifica* larvae seem to prefer to clamber among exposed tree roots at the edge of rivers and wave-washed lakes (Walker and Corbet 1975; R.A. Cannings, pers. comm.). Samways and Steytler (1996) provide recommendations for the width of riparian buffers and vegetation heterogeneity for odonate species assemblages. Although these recommendations do not directly treat *M. magnifica*, the life requirements of the dragonfly species are similar; these recommendations therefore may be used as starting points for a management plan for this species.

On Christina Creek, protection of riparian vegetation communities is being actively pursued by The Nature Conservancy of Canada through the creation of conservation covenants on the private land parcels along the stream (K. Blake, pers. comm.).

9.3 Recreation Management

Control of the amount and type of recreation in the habitat is also important.

In parks and other protected areas along lakeshores, I recommend restricting access to at least some areas of shoreline in order to maintain relatively natural littoral and shore zones there. A good example of this is the sandy/gravely shoreline immediately to the east of the main swimming beach in Sunoka Provincial Park. At the very least, no development of the foreshore in this area should be allowed and access by land should be restricted. This would not only benefit littoral species, but also allow the continued survival or even rehabilitation of the natural beach and riparian vegetation.

Also of particular concern is the use of personal watercraft along the rivers where this species lives; this is especially so on a narrow stream such as Christina Creek. The wakes from these craft break down the banks (observed directly at Christina Creek) and ultimately collapse the streamside vegetation (Cannings et al. 1999).

9.4 Introduced Species Management

Because introduced fish have undoubtedly had a negative impact on dragonfly larval density (Hilton 1997; Corbet 1999), especially in the Okanagan River and Christina Creek, one would expect that any control of their density would have a positive effect.

Control of Eurasian water-milfoil where it forms extensive, thick mats (e.g., at Vaseux Lake, north end of Okanagan Lake and outlet of Christina Lake) is probably advisable. However, the effect of this plant on the density of *M. magnifica* is unknown.

9.5 Pollution Control

No recent studies are available on the effects of eutrophication or pesticide contamination within the range of *M. magnifica* in British Columbia. All of the major centres within the Okanagan are putting their sewage through tertiary treatment plants, removing all nitrates and phosphates that would cause eutrophication of the downstream system. However, smaller centres and irrigation districts are not treating their sewage in this manner and fertilizer runoff is an additional concern.

10 EVALUATION

10.1 Conservation Data Centre Ranking

Number of Occurrences: B

Probably on the order of 15-20 occurrences in the province, following the NatureServe (2002a) definition.

Number of Occurrences with Good Viability: CD

No studies have been made to estimate viability, but at least 10 of the occurrences are probably of good viability (i.e., at least a 95% probability of persistence for 20 years).

Population Size: EF

No thorough inventories have been made to attempt to estimate population size, but the provincial population is probably at least 3000 and possibly greater than 10 000.

Range—Extent of Occurrence: F

Ranges from Cultus Lake north and east to Shuswap Lake, south to Christina Lake; an area of about 50 000 km2.

Area of Occupancy: LD

Taking the length of occupied streams and adding the length of occupied lake shorelines, this species occupies roughly 500 km of shoreline in British Columbia. By assuming 100 m average width of linear habitat, an area of about 50 km2 can be derived.

Short-term Trend in Population Size, Extent of Occurrence, Area of Occupancy, and/or Number or Condition of Occurrences: U

Unknown.

Long-term Trend in Population Size, Extent of Occurrence, Area of Occupancy, and/or Number or Condition of Occurrences: U

Unknown; although may have declined in population size and/or distribution in the Fraser Valley and along the Okanagan River.

Threats: B

Scope: Moderate (20-60% of population or area affected) for introduced fish and Eurasian water-milfoil; Low (5-20% affected) for habitat loss/degradation.

Severity: Moderate (major reduction of species population or long-term degradation or reduction of habitat in area affected) in terms of introduced fish and aquatic plants.

Imminence: High (threat is happening now).

Number of Appropriately Protected and Managed Occurrences: BC

Habitat protected in a number of provincial parks and other protected areas (see Section 3.4); however, no management is being undertaken in them to ensure protection from introduced fishes and Eurasian water-milfoil, and human recreation use.

10.2 Summary

There are probably on the order of 15-20 occurrences in the province, following the NatureServe (2002a) definition. However, some of these occurrences are quite extensive in area. No data or anecdotal accounts exist to indicate the species' historical abundance and distribution, and there have been no recent, thorough surveys—population sizes and trends are therefore impossible to determine. It may have declined in numbers and/or lost some populations following the channelling of the Okanagan River, and populations in the Fraser Valley may have declined. Because of its limited distribution in only a few warm rivers and lakes in the Fraser Valley and southern interior of British Columbia, and because these areas are subject to a number of threats (such as shoreline development, pesticide and other pollution, habitat degradation from unregulated recreational use, and predation/habitat alteration by introduced fish and aquatic plants), I recommend retaining the S3 ranking and Blue List designation of this species.

11 AUTHORITIES CONSULTED

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Appendix 1. Historical records of *Macromia magnifia* in British Columbia, 1909-2000.

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
Anstie Arm	Shuswap L. [=Anstey Arm]	1			Adult	E.R. Buckell	7	7	1942				51	4		118	56				Envelope	SEM
Anstie Arm	Shuswap L. [=Anstey Arm]	1			Adult	E.R. Buckell	7	8	1942				51	4		118	56				Envelope	SEM
Anstie Arm	Shuswap L. [=Anstey Arm]	1	1		Adult	E.R. Buckell	7	8	1942				51	4		118	56				Envelope	SEM
Anstie Arm	Shuswap L.	2			Adult	E.R. Buckell	7	8	1942				51	4		118	56				Alcohol	SEM
Anstie Arm	Shuswap L.	1			Adult	E.R. Buckell	7	8	1942				51	4		118	56				Alcohol	SEM
Anstie Arm	Shuswap L.	1			Adult	E.R. Buckell	7	8	1942				51	4		118	56				Pin	SEM
Chilliwack R.			1		Adult	W.E. Ricker	23	6	1936				49	6		121	58			"(Walker and Ricker, 1938)"		PUB
Christina L.		1	1		Adult	F.C. Whitehouse	10	7	1938				49	7		118	15				Pin	SEM
Christina L.		1	1		Adult	F.C. Whitehouse	11	7	1938				49	7		118	15				Pin	SEM
Christina Lake			1		Adult	"Whitehouse, Frank C."	8	7	1938				49	2	34	118	13	4			Envelope	RBCM
Cultus L.		5	2		Adult	"D.R. Paulson, M.L. Paulson"	14	7	1971				49	3		121	59					DRP
Cultus L.			1		Adult	F.C. Whitehouse	24	6	1936				49	3		121	59					CNC
Cultus L.			1		Adult	W.E. Ricker		5	1933				49	3		121	59			"teneral, (Walker and Ricker, 1938)"		PUB
Cultus L.				9	larvae	F.C. Whitehouse	28	5	1933				49	3		121	59			"no collector (Walker,		PUB

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection source
Cultus L.		1			Adult	W.E. Ricker		6	1933				49	3		121	59			"no day, teneral, Paratype, (Walker, 1937)"		PUB
Cultus L.		1			Adult	W.E. Ricker	5	7	1934				49	3		121	59			"Paratype, (Walker, 1937)"		PUB
Cultus L.		1			Adult	W.E. Ricker	5	8	1934				49	3		121	59			"(Walker and Ricker, 1938)"		PUB
Cultus L.		5	4		larvae	W.E. Ricker	28	5	1935				49	3		121	59			"nymphs, (Walker and Ricker 1938)".		PUB
Cultus L.		3			Adult	W.E. Ricker	26	6	1935				49	3		121	59			"plus exuviae, Paratype, (Walker, 1937)"		PUB
Cultus L.		2			Adult	W.E. Ricker	26	6	1935				49	3		121	59			"emerged 22:00 hr., (Walker and Ricker, 1938)"		PUB
Cultus L.		1			Adult	W.E. Ricker	3	7	1935				49	3		121	59			"Paratype, (Walker, 1937)"		PUB
Cultus L.		1			Adult	W.E. Ricker	3	7	1935				49	3		121	59			"emerged, (Walker and Ricker 1938)".		PUB
Cultus L.		1	3		larvae	W.E. Ricker	5	6	1936				49	3		121	59			"nymphs, (Walker and Ricker 1938)".		PUB

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection source
Cultu L.					larva	W.E. Ricker	12	6	1936				49	3		121	59			"1 nymph, (Walker and Ricker 1938)",		PUB
Cul s L.		1			Adult	W.E. Ricker	16	6	1936				49	3		121	59			"plus exuvia, Paratype, (Walker, 1937)"		
Cultus L.			1		Adult	W.E. Ricker	22	6	1936				49	3		121	59			"plus exuvia, Paratype, (Walker, 1937)"		PUB
Cultus L.			1		Adult	W.E. Ricker	22	6	1936				49	3		121	59			"emerged, (Walker and Ricker 1938)",		PUB
Cultus L.			1		Adult	W.E. Ricker	23	6	1936				49	3		121	59			"Allotype, (Walker, 1937)"		PUB
Cultus L.		4			exuviae	W.E. Ricker	23	6	1936				49	3		121	59			"exuviae, (Walker and Ricker 1938)",		PUB
Cultus L.		2			Adult	F.C. White-house	7	7	1936				49	3		121	59			"Paratype, (Walker, 1937)"		PUB
Cultus L.		2			Adult	F.C. White-house	7	7	1936				49	3		121	59			"(Walker and Ricker, 1938)"		PUB
Cultus L.			1		Adult	F.C. White-house	19	7	1936				49	3		121	59			"Paratype, (Walker, 1937)"		PUB
Cultus L.			1		Adult	F.C. White-house	19	7	1936				49	3		121	59			"(Walker and Ricker, 1938)"		PUB

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
Cultus L.		2			Adult	E. Robertson	5	7	1937				49	3		121	59			"(Walker and Ricker, 1938)"		PUB
Cultus L.		9			Adult	W.E. Ricker	10	7	1937				49	3		121	59			"08-12.07, (Walker and Ricker, 1938)"		PUB
Cultus L.			1		Adult	W.E. Ricker	26	7	1937				49	3		121	59			"(Walker and Ricker, 1938)"		PUB
Cultus L.		2			Adult	W.E. Ricker	15	8	1937				49	3		121	59			"(Walker and Ricker, 1938)"		PUB
Cultus L.		2			Adult	W.E. Ricker	10	9	1937				49	3		121	59			"(Walker r and Ricker, 1938)"		PUB
Cultus L.		1			Adult	W.E. Ricker	25	7	1934				49	3		121	59			"Holotype, (Walker, 1937)"		ROM
Cultus L.				1	exuviae	F.C. Whitehouse		6	1936				49	3		121	59			"exuvia, synoptic"	Pin	SEM
Cultus L.		1			Adult	F.C. Whitehouse	1	7	1936				49	3		121	59			synoptic	Pin	SEM
Cultus L.		1			Adult	F.C. Whitehouse	1	7	1936				49	3		121	59				Pin	SEM
Cultus L.			1		Adult	F.C. Whitehouse	1	7	1936				49	3		121	59				Pin	SEM
Cultus Lake		1			Adult	"Whitehouse, Frank C."	9	7	1936				49	3	58	121	58	4			Envelope	RBCM
Deep L.	Vernon				Adult	R.D. Bird	30	7	1931				50	12		119	13					CNC
Hope, Kawkawa Lake		1			Adult	"Whitehouse, Frank C."	28	7	1936				49	23	1	121	24	1			Envelope	RBCM

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
Kawkaw	Hope				Adult	F.C. Whitehouse	5	8	1936				49	23		121	24			"Paratype, (Walker, 1937)"		PUB
Madeline L.	"swamp valley W of Princeton" "[should be Penticton]"	1			Adult	"E. Kappes, W. Kappes"	29	7	1985				49	30		119	38			"found dead, Kappes & Kappes 1986"		PUB
Madeline L.	"swamp valley W of Princeton" "[should be Penticton]"				Adult	"E. Kappes, W. Kappes"	2	8	1985				49	30		119	38			"1, teneral, Kappes & Kappes 1986"		PUB
Mission Creek	near confluence with Pearson Creek	2		2	Adult	Dennis St. John	13	8	1997	11U	3523	55283							semi-open Douglas-fir forest next to willow/ poplar riparian	hunting along roadside	sight	RJC data
"Naramata, Chute Lake Road"	1.4 km above Glenfir junction	1			Adult	Richard J. Cannings	20	7	1997	11U	3130	55050							gravel road through second-growth Douglas-fir forest	patrolling road	Envelope	RBCM
"Naramata, Kettle Valley Railroad"	1st corner north of Smethurst Rd.	1			Adult	Richard J. Cannings	19	7	1997	11U	3139	54973							gravel track through ponderosa pine forest	"cruising up and down right-of-way; 2 others seen at this spot, 10 within 2 km"	Envelope	RBCM

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
"Naramata, Kettle Valley Railroad"	1st corner north of Smethurst Rd.	1			Adult	Richard J. Cannings	19	7	1997	11U	3139	54973							gravel track through ponderosa pine forest	"cruising up and down right-of-way; 2 others seen at this spot, 10 within 2 km"	Envelope	RBCM
"Naramata, Kettle Valley Railroad"	100 m. north of Smethurst Rd.	1	1		Adult	Richard J. Cannings	19	7	1997	11U	3144	54968							gravel track through ponderosa pine forest	old railway grade; 20+ seen over 7 km	Envelope	RBCM
"Naramata, Kettle Valley Railroad"	500 m N of Smethurst Road	1			Adult	Robert A. Cannings	26	7	1997	11U	3143	54971							gravel track through open ponderosa pine forest	cruising up and down old railway grade; 20+ seen over 7 km	Envelope	RBCM
"Naramata, Kettle Valley Railroad"	500 m N of Smethurst Road	1	1		Adult	Russell C. Cannings	26	7	1997	11U	3143	54971							gravel track through open ponderosa pine forest	cruising up and down old railway grade; 20+ seen over 7 km	Envelope	RBCM
"Naramata, Kettle Valley Railroad"	Little Tunnel	1			Adult	Richard J. Cannings	26	7	1997	11U	3125	55002							gravel track through open ponderosa pine forest	cruising up and down old railway grade; 20+ seen over 7 km	Envelope	RBCM
"Naramata, Kettle Valley Railroad"	Robinson Cr. @ lower track	1			Adult	Richard J. Cannings	21	8	1997	11U	3138	54988							gravel track through ponderosa pine forest	"cruising up and down track, 20 cm off ground"	Envelope	RBCM

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
"Naramata, Kettle Valley Railroad"	1.4 km S of Little Tunnel	1			Adult	Richard J. Cannings	2	9	1997	11U	3134	54993							gravel track through ponderosa pine forest	cruising straight up and down track 20 cm above ground	Envelope	RBCM
"Naramata Kettle Valley Railroad"	1st corner north of Smethurst Rd.	2			Adult	Richard J. Cannings	8	9	1997	11U	3139	54973							gravel track through ponderosa pine forest	seen cruising up and down track	sight	RJC data
"Naramata, Kettle Valley Railroad"	1st corner north of Smethurst Rd.	1			Adult	Richard J. Cannings	9	9	1997	11U	3139	54973							gravel track through ponderosa pine forest	"cruising up and down right-of-way; 2 others seen at this spot, 10 within 2 km"	Envelope	RBCM
"Naramata Manitou Beach"		1			Adult	Russell C. Cannings	22	7	1997	11U	3124	54964							sand/ gravel beach in small bay	seen cruising over water 10 m from shore	sight	RJC data
Osoyoos L.	N end	1			Adult	S.G. Cannings	6	9	1982				49	4		119	31				Envelope	SEM
Osoyoos L.		1			Adult	S.G. Cannings	1	7	1974				49	2		119	27				Envelope	SEM
"Osoyoos Lake, Haynes Lease Ecological Reserve"		1			Adult	"Cannings, Sydney G."	6	9	1980				49	4	49	119	30	46			Envelope	RBCM
Peachland		1			Adult	J.B. Wallis	24	7	1909				49	46		119	44			"first record for Canada, Ent. Soc. Ont. 1909"		PUB

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
Peachland		1			Adult	J.B. Wallis	31	7	1909				49	46		119	44			Ent. Soc. Ont. 1909 (pub'10)		PUB
Penticton	King's Park	1		1	Adult	Richard J. Cannings	20	9	1997	11U	3117	54852							grass playing field	"cruising over field, perched 5 m up in tree"	sight	
Penticton		1			Adult	F.C. White-house	9	7	1938				49	30		119	35			"listed under M. pacifica, prob. this species"		CNC
Penticton		1			Adult	F.C. White-house	18	7	1938				49	30		119	35				Pin	SEM
Penticton		1			Adult	F.C. White-house	18	7	1938				49	30		119	35			synoptic	Pin	SEM
Penticton		1			Adult	"White-house, Frank C."	18	7	1938				49	30		119	35				Envelope	RBCM
Salmon Arm		1			Adult	A.A. Dennys	25	6	1925				50	42		119	16					CNC
Salmon Arm					Adult	E.R. Buckell	12	7	1935				50	42		119	16					CNC
Salmon Arm		1			Adult	E.R. Buckell	12	7	1935				50	42		119	16			paratype	Alcohol	SEM
Shuswap L.		1			Adult	E.R. Buckell	7	7	1942				50	56		119	17				Alcohol	SEM
Sicamous		1			Adult				1998											"no collector, no day/month'	Pin	R. Kenner
Summer-land	Okanagan L.				exuviae	M. Poncelet	14	8	2000				49	36		119	40				Pin	SEM
Summer-land	Okanagan L.				exuviae	M. Poncelet	20	8	2000				49	36		119	40				Pin	SEM
Sweltzer Cr.		1			Adult	E. Robertson	14	8	1936				49	5		121	59			"(Walker and Ricker, 1938)"		PUB

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
Trout Cr. Pt.	Summer land			1	larva	S.G. Cannings	13	7	1974				49	34		119	37			"larva, died in failed emergence	Pin	SEM
Vaseux L.	2-5 m out over water	1			Adult	R.A. Cannings	19	6	1978			4	9	17		119	32			"13-14:00 patrolling water 1-2m deep, Chara abundan"	Alcohol	SEM
Vaseux L.	"hills to E 2000' el., ponderosa pine/ Douglas fir forest "		1		Adult	R.J. Cannings	13	6	1983				49	18		119	30	30			Envelope	SEM
Vaseux L.	"water 1-2 m deep, on underside of Ponderosa log"				exuviae	R.A. Cannings	19	6	1978			4	9	17		119	32				Alcohol	SEM
Vaseux L.		1			Adult	R.J. Cannings	4	8	1984				49	17		119	32				Envelope	SEM
Vaseux L.		1			Adult	R.J. Cannings	4	8	1984				49	17		119	32				Envelope	SEM
Vaseux L		1			Adult	R.J. Cannings	4	8	1984				49	17		119	32				Envelope	SEM
Vaseux L.		1			Adult	R.J. Cannings	4	8	1984				49	17		119	32				Envelope	SEM
Vaseux L.			1		Adult	S.G Cannings	4	8	1984				49	17		119	32				Envelope	SEM
Vaseux L.	lagoons	1			Adult	R.A Cannings	19	6	1978			4	9	16		119	32			dorsal view	Photo	RBCM

Appendix 1. Continued

Location	Location cont'd	m	f	unk		Collector	day	mo	year	zone	E	N	lat	min	sec	long	min	sec	habitat	comments	specimen	collection/ source
Vaseux Lake Park				1	Adult	"Cannings Sydney G."	18	6	1989				49	17	58					error in longitude; not presented here	Envelope	RBCM
"Vaseux Lake, lagoons at s. end"		1			Adult	"Cannings Robert A."	17	7	1981				49	16	20	119	31	56			Envelope	RBCM
"Vaseux Lake, west side"	150 m S of Metcalf's	1			Adult	Dennis St. John	16	7	1997	11U	3148	54643							gravel road along lake		Envelope	RBCM